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NATIONAL GOALS IN AIR POLLUTION RESEARCH

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National Goals in Air Pollution Research

Report of the Surgeon General's Ad Hoc Task Group on Air Pollution Research Goals

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II

The Surgeon General's Ad Hoc Task Group on Air Pollution Research Goals

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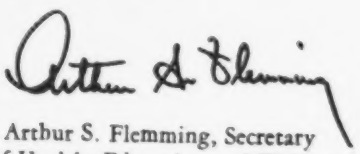
"As I have had the opportunity of working with my associates on problems in this and other areas, I have developed a growing conviction that if, as a society, we are going to deal effectively with such problems, it is going to be necessary for us to reach agreement on what I like to think of as national goals.

"There is no doubt at all but that if we are to move forward in dealing with this particular problem, it will be necessary for us as a society to make a substantial investment in research activity. I would hope that we could reach agreement as to what constitutes a fair share of the total investment for the Federal Government, for State governments, for local communities, and for business and industry.

"In other words, having agreed on the total amount, how much should we invest in the way of public dollars, and how much should we invest in the way of private dollars?"



Arthur S. Flemming, Secretary
U.S. Department of Health, Education and Welfare

Speaking before the National Conference on Air Pollution, November 20, 1958

IV

Foreword

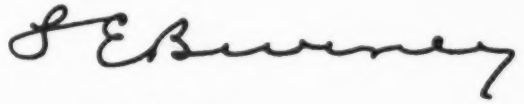
The problem of air pollution, like many challenges of our modern environment, can be resolved only by a balanced partnership among many agencies and interests. Designing such a partnership and apportioning a just share of responsibility to each of its members require a high degree of cooperation among the groups concerned.

In response to Secretary Flemming's call for agreement on mutual goals and individual responsibilities, therefore, I invited some of the ablest men in their fields to serve as a Task Group on Air Pollution Research Goals.

This Report on "National Goals in Air Pollution Research" represents the consensus of this group, after a year of intensive study and deliberation. It is a tribute to the conscientious and cooperative spirit of these men, representing a great diversity of interests and disciplines, that they were able to reach unanimous agreement on recommendations concerning the nature and scope of research goals and an equitable distribution of the costs involved.

The National Advisory Committee on Air Pollution has reviewed this Report and congratulated the Task Group on their product. To this I should like to add my own wholehearted appreciation, and to second the Committee's recommendation that the Report be given wide dissemination for study and discussion by all concerned with the air pollution problem.

I am convinced that this Report provides a sound basis upon which to develop the nation's potential for air pollution research. It now remains for the Federal Government, the States and communities, business and industry, and the general public to accept their responsibilities in good faith and mutual understanding. No amount of planning will solve the nation's air pollution problem unless the plans are carried out.



Leroy E. Burney
Surgeon General

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Summary and Recommendations

This Report by the Surgeon General's Ad Hoc Task Group on Air Pollution Research Goals is concerned with the nationwide needs within the next 10 years for research on the growing problems of community air pollution. It outlines specifically the Task Group's conclusions as to: (a) the identification of national goals for air pollution research; (b) the costs of such research; and (c) the recommended allocations of financial responsibility among the Federal Government, States and local governments, and industry, for the several aspects of such research.

Air pollution in urban areas involves the emission of a broad variety of gases, fumes, and solids, some in large quantities, followed by chemical and physical reactions among them in the open air. The pollutants derive from many and diverse activities of the population—from homes, transport vehicles, and places of work.

In many locations, the air resource has limited capacity to dilute and disperse pollutants discharged to it. The concentration of pollutants in the air at any time depends upon the interplay of three principal factors: (1) the quantity and kind being emitted; (2) the vertical and horizontal aerial dispersion of the pollutants; and (3) the chemical and physical reactions which alter the pollutants in the air.

Research in air pollution is concerned primarily with ascertaining its effects on the health of the exposed population. Indeed, safeguarding the health of the public is the most compelling reason for extending Federal assistance on community air pollution problems. Although the health effects of air pollution are in general diffuse and difficult to measure, several serious air pollution episodes have occurred which resulted in acute illness and death. Of even greater health significance, however, may be the relationship of air pollutants to chronic respiratory and cardiorespiratory ailments and cancer.

Air pollution has many other adverse effects, however, such as economic losses due to damage to vegetation and livestock, corrosion of materials, soiling of surfaces, and reduction in visibility. Economic damages in the United States from air pollution have been estimated at billions of dollars annually. There are also nuisance and psychological effects, primarily due to irritation of the senses such as malodors and eye irritation.

Projections of the increase in population, of its further concentration in urban areas, and of continued growth and increase in complexity

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of our economy, all point to increasing potential for air pollution in our urban areas.

A broad expansion of the nationwide effort on air pollution research is required to provide the technical and scientific bases for coping with present and future problems. In considering the total research effort needed, the Task Group identified ten principal goals for detailed consideration: (1) Effects on Man, (2) Agricultural Effects, (3) Economic Losses Due to Damage to Materials, Soiling, and Reduced Visibility, (4) Measurement and Identification, (5) Meteorology, (6) Atmospheric Reactions, (7) Surveys and Monitoring, (8) Control, (9) Information, Education, and Training, and (10) Administrative and Legal Aspects. Table 1 summarizes the recommended levels of research activity for each of these, the timing involved, and the respective financial responsibilities of the Federal Government, industry, and the States and local governments. It should be emphasized that the various research elements are interrelated, that progress in some is dependent on basic work in others, and that the elements together thus form an integrated program.

Since costs vary widely, depending upon the nature of the research, the levels of effort recommended do not necessarily reflect the relative importance of the various goals. Thus, in instances where the funds are relatively small, the goals are, nevertheless, very important.

In total, the recommendations call for about a 3-fold progressive increase in the nationwide air pollution research effort from the current estimated level of about $11 million annually to approximately $32 million per year by 1968. Of this maximum annual expenditure, about 40 percent is considered the responsibility of the Federal Government, 28 percent the responsibility of industry, and 32 percent the responsibility of States and local governments. In the allocation of these responsibilities, the Task Group has used the following as general criteria: (a) the Federal Government should be largely responsible for research of a broad nature and of general applicability such as determining criteria for air quality; for the collection, integration, and communication of information; and for the training of specialized personnel; (b) industry's responsibility for air pollution research, although it extends in varying degree to each of the goals, relates primarily to the development of adequate and economical control equipment and procedures, and to other studies specific to individual industry emissions; and (c) States and local governments have responsibility to support research of primary interest to them and to survey and evaluate the air pollution problems of their respective jurisdictions.

To implement the recommendations of this Report it will first

be necessary to bring them to the attention of all parties concerned. This requires that the recommendations be circulated widely to appropriate Federal, State, and local officials, to representatives of industry, and to the public. It will be particularly important that the research needs be brought to the attention of Federal, State, and local elected officials who have responsibility for their implementation through appropriate legislative enactment and appropriation of funds.

Since the implementation of the air pollution research goals herein outlined will require the active participation and collaboration of respective levels of government and of industry and the public, it is recommended that all parties be informed of the content of this Report. It is further recommended that discussion and comment on the Report be encouraged by means of appropriate actions by responsible individuals and organizations such as the Secretary, Department of Health, Education, and Welfare; the Surgeon General, United States Public Health Service; the Council of State Governments; the United States Conference of Mayors; the Governors' Conference; the American Municipal Association; the National Association of County Officials; official representatives of industries and industrial organizations concerned with the air pollution problem; the Air Pollution Control Association; and other interested technical and professional societies.

Introduction

Origin of Report.

Nationwide problems of air pollution have been growing steadily. To help determine what the Nation should do to deal with these problems, Dr. Leroy E. Burney, Surgeon General of the Public Health Service, called the National Conference on Air Pollution, held in Washington, D.C., in November 1958. The recommendations of the Conference stressed the need for intensified research into the nature, causes, effects, and abatement of air pollution.

Addressing the Conference, Dr. Arthur S. Flemming, Secretary of Health, Education, and Welfare, emphasized the need for agreement on national goals for air pollution research. In recognizing the substantial investment required in such research, Dr. Flemming asked the following questions: How much should be invested in what kinds of research over how long a period? How much each year? What constitutes a fair share of this amount to be assumed by the various levels of government (Federal, State, and local) and by business and industry? To answer these questions, the Surgeon General appointed the Ad Hoc Task Group on Air Pollution Research Goals, composed of individuals from various public and private organizations and skilled in several professional disciplines which have a relation to air polution problems.

This Report of the Ad Hoc Task Group is submitted in response to Secretary Flemming's request for: (a) identification of national goals for air pollution research; (b) the cost of such research; and (c) recommended allocations of financial responsibility for the several aspects of such research.

Definition of "Research."

For purposes of this Report, the Task Group agreed that research should be defined as anything that adds to the fund of knowledge on the causes, sources, control, and effects of air pollution, including developmental work related to control.

Air Pollution Problems

Air pollution, for the purposes of this Report, is defined as the presence in the ambient atmosphere of substances put there by the activities of man in concentrations sufficient to interfere directly or indirectly with his health, safety, or comfort, or with the full use and enjoyment of his property. In general, this definition does not refer to the atmospheric pollution incident to employment under special occupational circumstances, nor to acts of war.

Unpolluted air is a mixture of nitrogen, oxygen, water vapor, carbon dioxide, and a few rare gases. Fortunately, nature has provided a huge reservoir of this mixture of gases and the temperature changes on earth necessary to ensure constant mixing of man's contaminants by air currents. However, these natural processes sometimes proceed at a slow rate. Whenever man's activities discharge to the air noxious or troublesome substances at rates faster than those forces operating to disperse or destroy them, a buildup in pollution concentration occurs and persists until natural forces can again cope with the situation.

Smoke as an air pollutant was prominent in many industrialized cities in Europe and the United States a century or more ago. In many areas of the United States, smoke abatement programs have attained considerable success, due to improved technology in fuel combustion, the availability of additional types of fuels adaptable to smokeless combustion in domestic and other uses, the development of measures for removing suspended particles from stack gases, and the development of abatement programs understood and accepted by the public.

Today, the concern with air pollution in urban areas relates to the emission of a variety of gases, fumes, and solids, followed by chemical reactions and physical combinations among them in the open air. The pollutants potentially come from incomplete combustion of various fuels and wastes in home and factory, from automobiles and other vehicles, from evaporation of many volatile substances in common use, and from processes resulting in evolution of dusts, fumes, or gases. In short, from many and diverse activities a great variety of polluting materials is discharged to the air, some in large quantities.

The concentration of pollutants in the air at any time depends upon the interplay of several factors, such as the quantity being emitted, the vertical and horizontal dispersion of the pollutants from

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the source, and the chemical and physical reactions which alter the pollutants in the air.

The need for a breadth of scientific understanding and attention, in dealing with community air pollution, far beyond the scope of yesterday's smoke abatement activities first received recognition in Los Angeles in the early 1940's. There for the first time in a large city, air pollution was seen as a phenomenon which could not be completely equated with smoke. Solid fuels were hardly used at all, yet air pollution came and grew. Los Angeles "smog," which persists as a critical problem despite ten years of control action more costly and restrictive than any ever before placed on citizens and industries by any government, stands as a warning to the rest of the nation. Evidence points to the probability that the problems faced by Los Angeles are not unique. The same kinds of plant damage caused by the oxidizing-type air pollution have been observed, not only elsewhere in California, but also in many other parts of the country.

Recent evidence has made clear that all metropolitan areas have limited air resources. Weather is predictable to a considerable degree, but it is still uncontrollable. Since this is so, man runs the risk of repetition of air pollution disasters in some cities. Awareness of the danger is reflected in the growing interest in the prediction of weather conditions conducive to the retention of pollutants. Even in areas where the meteorological circumstances are favorable, air resources are being heavily loaded and in some cases acceptable concentration limits have been exceeded.

Air pollution adversely affects man in many ways; at times and under certain circumstances the effects have been serious. Outstanding among the several recorded episodes when air pollution was the immediate cause of illness and death are the Meuse Valley, Belgium, where one hundred were made ill and sixty-three died in 1930; the Donora, Pennsylvania, episode of 1948 when over a thousand persons were severely affected and twenty died; and the London, England, episode of 1952 when four thousand excess deaths were recorded during a two-week period in December.

Just as important, and perhaps more difficult to deal with than the occurrence of acute episodes, is the possibility that air pollution may be responsible for chronic health impairment in our population. Statistical studies of mortality and morbidity of human populations and laboratory studies of animals suggest relationships between air pollution and the incidence of lung cancer. Similar relationships are seen with regard to cancer of the stomach and esophagus, heart disease,

and several respiratory ailments, such as emphysema and chronic bronchitis. In addition, air pollution can act upon exposed mucous membranes, causing eye, throat, and nasal irritation. Such irritation, combined with the general nuisance effects of air pollution, produces an as yet unmeasured but perhaps significant amount of psychological harm to the people in our urban areas.

Air pollution affects man in many other important ways. It is estimated to cost America billions of dollars annually in soiling and corrosion alone. It damages vegetation and livestock and, by reducing visibility, creates hazards for ground and air traffic. It interferes with man's enjoyment of his surroundings, contributes greatly to the physical deterioration of communities, constitutes a variety of annoyances, and is frequently offensive to the senses.

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Air Pollution Trends

The trends of modern living involve increasing emphasis on many personal, community, and industrial activities which contribute directly to both the intensity and complexity of air pollution. It seems clear that the factors responsible for today's community air pollution will experience accelerated growth in the future. By 1970, it is expected that our national population will be about 214 million*—an increase of 20 percent over the present. Over one-half of the present population of the United States lives in 192 metropolitan areas, which constitute less than 10 percent of the land area of the country. There is every indication that the tendency to concentrate in urbanized areas will continue, to the extent that approximately two-thirds of the population increase in the next 10 years will locate in these areas.

Thus, it can readily be seen that a major portion of the waste products discharged to the atmosphere will continue to be released into relatively small segments of the air mass. Data from the National Air Sampling Network demonstrate generally a progressive increase in particulate air pollution concentration with increase in city size. As our metropolitan areas grow larger and coalesce, the air pollution potential becomes greater.

The Gross National Product is a general broad index of the total economic capacity of the nation to produce, to use, and to consume goods and services. It therefore serves to connote an order of magnitude of pollution-producing activities. It also indicates the ability of public and private interests to support research and control programs, and to provide abatement measures.

The GNP, in terms of constant prices, has increased over a long period at a compound rate of about 3 percent per year. The rate of growth between 1946 and 1959 was about 3¼ percent per year. At this rate, the Gross National Product would amount to $660 billion by 1970, as compared to $479 billion in 1959.** A comparison between GNP and total national research and development expenditures is a measure of the "relative intensity" of research. Total national research and development expenditures recently have risen at a faster rate than the Gross National Product. Annual outlay for research

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*Source: Bureau of the Census, Current Population Reports: Population Estimates, No. 187.

**Source: Economic Report of the President, January 1960.

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and development is estimated to have increased from $1.5 billion in 1945 to over $12 billion in 1960.*

The total national expenditure for research and development is not only indicative of the ability of public and private interests to support air pollution research, but is important also in relation to the nature of the air pollution problem. A greatly expanded research and development activity will result in the creation of new processes and products which in turn will create new, and inevitably more complex, air pollution problems.

These trends of growth suggest a standard of living in the reasonable future considerably higher than at present. At the same time they will increase the air pollution potential in our urban areas, where the greater part of the growth in population and economic activity will occur.

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*Source: National Science Foundation, Reviews of Data on Research and Development, December 1959.

Specific Goals In Air Pollution Research

Determination of Specific Goals.

In order to arrive at the total research effort needed in the air pollution field, the research tasks have been divided into ten subgroupings for detailed consideration. The specific research subgroupings for which national goals are recommended in the form of time-phasing and levels of effort by the Federal Government, industry, and States and local communities are: (1) Effects on Man, (2) Agricultural Effects, (3) Economic Losses Due to Corrosion, Soiling, and Reduced Visibility, (4) Measurement and Indentification, (5) Meteorology, (6) Atmospheric Reactions, (7) Surveys and Monitoring, (8) Control, (9) Information, Education, and Training, (10) Administrative and Legal Aspects.

The estimated present levels of effort on each goal are based on the best information available to the Ad Hoc Task Group. Although the data in some instances were meager, the collective experience and resources available to the members of the Task Group resulted in independent estimates which were in reasonably good agreement. Individually and collectively, the Task Group arrived at the final goal figures through the following process: (1) the known research projects and the current efforts of researchers in the field were evaluated as to nature of the work, cost, and source of funds; (2) adjustments in certain goals were made in light of the relative need for more information in these areas; (3) a gross extrapolation was made for a 10-year period to obtain agreement on a reasonable total level of effort, after which each goal was subjected to individual analysis; and finally (4) consideration was given to specific major problems which can be anticipated, and the estimates were adjusted accordingly.

Once a reasonable level of total effort was agreed upon, the individual goals were adjusted in accordance with the relative need. It should perhaps be emphasized that the recommended levels of effort are considered reasonable and attainable and are not to be construed as maximum expenditures or "crash" programs.

Facilities and Manpower—General.

The cost of an adequate research program in air pollution is relatively small compared with the estimated total expenditures for

research and development in the United States during the next decade, being on the order of one-tenth of one percent. The percentage of the nation's trained manpower and research facilities required for air pollution studies likewise will be small.

The most important and least predictable factor affecting the availability of resources for air pollution research, both in manpower and facilities, is the relative priorities of the air pollution program and other national research programs such as those concerned with defense, missiles, and peaceful uses of atomic energy. Whether or not the facilities and manpower to support the levels of effort recommended in this Report will be available at the time of need depends to a very great extent on the world situation, the rate of total development of our nation's technology, and the advent of new industrial or governmental scientific enterprises. At this time it appears probable that recent high rates of growth of national expenditures for research and development will be continued for the next 10–15 years at least. This total national research and development activity will require increased numbers of scientists and engineers. For the purposes of this report, it is assumed that larger numbers of individuals with the necessary competence in the various disciplines involved will be graduated from our academic institutions. This Report, therefore, will consider education and training needs only as they are related to unique requirements for air pollution research.

A special effort should be made to encourage graduate students in appropriate disciplines to engage in research on air pollution problems. Adequate manpower trained in the unique phases of air pollution research such as atmospheric sampling, community surveys, and control methods is not available at the present time. Opportunity should be provided to scientists and engineers to familiarize themselves with air pollution problems so that they may more effectively apply their technical competence to research in this field. Only by making specialized training available to interested graduates and by providing support for postdoctoral research will a sufficient number of competent persons be provided to staff the Federal, industry, and State and community efforts recommended in this report.

In line with this concept of the needs for manpower in air pollution research, there are included in Goal 9 specific estimates to meet the requirements.

The research facilities required are in general of the same type as those for other scientific research programs, particularly those dealing with other environmental health hazards. This being the case, it is recommended that general facilities for environmental health

research in the future be adequate to accommodate the air pollution research program and that they be designed to include those facilities unique to this field.

Consideration of future total requirements for general environmental health research facilities is beyond the scope of this Report and is, therefore, not included.

Responsibility for Research.

Responsibility for research as used in this Report and as represented by dollar values refers to responsibility for providing the funds to support the research programs. It does not imply that the responsible parties must conduct their own research or that they could not conduct programs with funds provided by one of the other parties. All responsible parties would utilize their research funds directly in their own facilities, through contracts, or by grants, as may be most advantageous.

As to the nature and extent of the research to be funded, the Federal Government should be largely responsible for research of a broad nature and of general applicability throughout the country, and for the training of specialized personnel. In addition, the Federal Government should have primary responsibility for development of information required to establish air quality standards, and for the collection and distribution of information.

The States and communities have a responsibility to support research on problems of primary interest to them, and to survey and evaluate continuously or intermittently the air pollution problems within their respective jurisdictions.

Although industry's responsibility for research in air pollution extends in varying degree to all the goals, the major contribution to be expected of industry relates primarily to the development of adequate and economical control equipment and procedures. As used in this Report, industry is intended to include business, commerical, manufacturing, and other activities involved in the production and exchange of goods. This definition would include agriculture, real estate (e.g., apartment houses), and government agencies when these are sources of air pollution. The control of contaminants at industrial sources is solely the responsibility of the industry concerned. It is reasonable to assume, therefore, that the costs of research involved in the development of control processes and equipment is largely the responsibility of industry. To realize the maximum return on in-

dustry's investment in air pollution research, perhaps even to qualify it as a contribution to the national effort, requires that the information obtained by industry be available for integration with the general fund of knowledge.

Funds from private sources such as research foundations and philanthropic organizations may also be available. A number of voluntary organizations, particularly those concerned with health research, have a real stake in this matter and should be encouraged to participate fully. The role of the universities and nonprofit research institutes will largely be confined to the conduct of research, the education and training of personnel, and the provision of consulting services. With the exception of some State-supported universities these organizations cannot be expected to provide significant support for research on air pollution problems with their own funds.

Although this Report is concerned only with responsibilities for research, the committee is not unmindful that the full costs of enforcement will fall on the States and communities and that the entire cost of control of industrial sources must be borne by industry. On the other hand it must be realized that all such costs are ultimately borne by the public, so that in the final analysis it becomes a matter of how much society is willing to pay for research, control, and enforcement to maintain a clean and healthful environment.

The Goals

Goal 1.

EFFECTS ON MAN: The goals of medical research in air pollution are: (a) to determine the effects of air pollution on human health, (b) to establish the identity of agents and mechanisms involved in the production of such effects, and (c) to identify the pollutants which produce undesirable sensory response in humans, and the mechanisms of their action.

Among the possible health effects which must be investigated are:

(1) Death or sudden, severe illness resulting from excessively heavy concentrations of pollutants. In this country such conditions are now believed to occur only under unusual atmospheric conditions.

(2) Aggravations and exacerbations of the illnesses of people already afflicted with chronic impairments and diseases. These may range from mild to severe.

(3) Increased incidence of certain diseases beyond the numbers "normally" expected to occur in specific population groups. Diseases of particular concern include lung cancer and chronic bronchitis.

(4) Specific diseases which may be a direct result of exposures to air pollution.

(5) Other specific diseases which may result from the combined effect of air pollution and at least one other environmental stress and/or hereditary defect.

In Goal 1–a, efforts are concentrated upon searching for finite effects in human populations, by means of morbidity and mortality surveys, analysis of health records, hospital records, etc. These data must then be compared with the types and concentrations of air pollutants to which the study populations have been, or are being, exposed.

In Goal 1–b, the mechanisms by which air pollutants produce or induce health effects are sought. Later, preventive or therapeutic measures may have to be developed. Studies of mechanisms must initially depend largely upon laboratory investigations, primarily of the intact animal or of isolated biologic systems. Findings of

these studies will then be "fed back" to investigations on humans to confirm their applicability to man.

The exposure of humans or animals to air pollutants may cause immediate obvious sensory responses such as eye irritation or minute sensory responses difficult to detect in animals or men. The nuisance value of the former and the potential health significance of both require more reliable and detailed evaluation. Goal 1–c provides for research on these problems.

In the conduct of research under Goals 1–a, 1–b, and 1–c considerable overlap is to be expected, and studies in one area may produce results of value in one or both of the other areas. The values for recommended levels of effort assigned to the subgoals therefore are arbitrary and should not be accorded undue significance.

In brief, Goal 1–a is concerned with *what* health effects air pollution causes in human beings; Goal 1–b is concerned with *how* these effects are caused; and Goal 1–c is concerned with sensory effects—the identification of agents and the mechanism of their action. The specific objectives and general nature of the research problems in these three areas are described below:

> Goal 1–a. *Health Surveys:* To determine the health status of groups of people living in areas of varying, known exposure to air pollution, and to relate the observed variations in health status to variations found in air pollution exposure, other environmental stresses being taken into consideration.

Improved epidemiologic and demographic investigations of the effects of air pollution upon existing human populations will be necessary. The success of these investigations in producing useful results will depend to a considerable degree upon the development of equipment and experimental designs which will be more sensitive in discriminating between air pollution and other causes. Such studies must be done in conjunction with environmental studies, including aerometric and meteorological evaluations.

Research in this area is concerned with problems of determining the biological effects of differing concentrations of pollutants acting over varying periods of time. Of prime concern is the measurement of effects that may result from extended exposure to low concentrations. In addition, research is faced with the problem of defining effects which may vary as pollutants are mixed and interact, often adding to or altering the biological effectiveness of others. Finally, a toxic or otherwise biologically effective agent may cause

different effects or diseases, dependent on its mode of administration, and many different environmental agents may produce the same disease or effect Thus, it is difficult to segregate air pollution and specific pollutants from all the other exposures and factors influencing man's health. The solution of these problems in air pollution research may effectively contribute to the understanding of other environmental health problems.

Goal 1–a

Estimated present effort, FY 1960.....		$600,000
Recommended level of effort:		
Federal Government..	$3,200,000	
Industry.....	250,000	
States & communities.	1,300,000	
Total annual effort.....		$4,750,000

The recommended level of effort should be reached in 5 years and maintained for the remainder of the 10-year period.

Goal 1–b. *Pathology and Physiology:* To determine the causal relationships and biological mechanisms involved in the action of air pollutants, individually and in combination, on human beings.

Although the *objective* of these studies is to determine how air pollution affects man, the necessary limitations on human experimentation require that most of the studies utilize animals, organ systems, or even more basically, tissue cultures and enzyme systems.

In the development of current and future research, priority is being given to studies based on the hypothesis that the most significant health effects of air pollution are those resulting from lifelong exposures to the relatively low levels of pollution that characterize the urban American environment. Unfortunately, these are also the effects that are most difficult to measure and that take the longest time to determine.

Consequently, considerable attention must be placed on efforts to develop improved procedures for study of the effects of air pollutants on animals and on man. The latter approach, for example, may be most effective for determining the action of air pollutants on physiological function where the effect is near the threshold level, and reversible. Particular attention needs to be given to increasing the

sensitivity of detection of effects over the relatively crude procedures currently employed in toxicological studies. This should lead to more effective tools for the assessment of subtle physiological and pathological changes and may provide procedures for the objective measurement of phenomena now in the gray area between health damage and physiologic "unpleasantness," such as eye irritation and nauseating odors, which are included in Goal 1–c.

Although principal reliance must be placed on studies of exposure of intact animals and, when possible, of man, some research utilizing biological systems such as plants, invertebrates, microorganisms, tissue cultures, enzyme systems, etc. will be required for clarification of mechanisms of action and, in some instances, for the development of procedures for the biological analysis of air pollutants.

The animal studies should include an increased emphasis on attempts to refine procedures for the evaluation of cardiac and respiratory stresses and cancer induction from air pollutants; in this field also, present experimental approaches have many deficiencies and work aimed at improved methods will be required.

Goal 1–b.

Estimated present effort, FY 1960		$1,000,000
Recommended level of effort:		
Federal Government	$2,100,000	
Industry	600,000	
States & communities	300,000	
Total annual effort		$3,000,000

The recommended level of effort should be reached in 5 years and maintained for the remainder of the 10-year period.

Goal 1–c. *Annoyance Effects—Irritation of the Senses:* To identify air pollutants which produce undesirable responses by the senses and to determine their mechanism of action and effective concentrations.

The aspects of air pollution which are most apparent and of greatest personal concern to the individual probably are irritation to the eyes, nose, and throat, malodors, and the reduction of visibility. The pollutants responsible for these effects are undesirable whether or not they cause long-range health effects or economic losses, because

they constitute an annoyance to people. The nuisance aspects of these effects together with those related to soiling give rise to the greatest number of complaints received by air pollution control authorities. There is no doubt that a person's well-being is eventually affected by exposure to these sensory annoyances and that this may result in economic loss.

Research is required to identify the direct or indirect causative agents and the concentrations at which they constitute a nuisance. Knowledge of specific causes and the mechanism of the undesirable or irritating action might suggest remedial or protective measures in urban areas short of removal from the air of all contaminants.

Goal 1–c.

Estimated present effort, FY 1960.....		$200,000
Recommended level of effort:		
Federal Government..	$500,000	
Industry.....	300,000	
States & communities.	200,000	
Total annual effort.....		$1,000,000

The recommended level of effort should be reached in 3 years, maintained for 5 years, and then decreased for the remainder of the 10-year period.

Goal 2.

AGRICULTURAL EFFECTS: To determine the effects on the agricultural economy caused by air pollution damage to vegetation and animals, and to identify the causative agents, their effective concentrations, and their mechanisms of action.

Goal 2–a. *Surveys:* To conduct surveys to assess the extent of damage to vegetation and livestock and to estimate the economic loss to the community, the State, and the nation.

It has been estimated that the annual loss of food and fiber crops in the Los Angeles area alone is in excess of $5 million dollars.* Ex-

*Source: Middleton, John T., Darley, E. F., and Brewer, R. F. Damage to vegetation from polluted atmospheres. Proc. Amer. Petrol. Inst. Sect. III. Refining. pp. 184-191. 1957.

tensive losses have also been cited in many other States, particularly Oregon, Washington, Montana, Idaho, Utah, Tennessee, Florida, and New Jersey. The damage in these areas has ranged from a slight reduction in crop yields to the loss of entire farm enterprises. Agricultural losses have been increasing annually. It is highly desirable that the nature and extent of such losses be assessed throughout the country on a continuing basis. Such assessment data are essential as background information for research and control activities associated with the agricultural effects of air pollution.

Goal 2–a.

Estimated present effort, FY 1960		$550,000
Recommended level of effort:		
Federal Government	$100,000	
Industry	900,000	
States & communities	500,000	
Total annual effort		$1,500,000

The recommended level of effort should be reached in 3 years and maintained for the remainder of the 10-year period.

Goal 2–b. *Mechanisms:* To identify the causative agents, effective concentrations, and mechanisms of action by which air pollutants damage vegetation and livestock.

Currently, air pollutants known to affect agriculture importantly and to require research investigation include fluorine-containing compounds, oxidants such as ozone, ethylene and other low-weight unsaturated hydrocarbons. Sulfur dioxide has long been recognized as responsibile for specific damage to vegetation and already has been extensively investigated.

In order to provide sound legislation, reasonable standards, and effective control programs, it is necessary to identify specific causative agents and to establish their levels of toxicity to various species of plants and to animals. A knowledge of the mechanisms involved in producing the damage might suggest effective protective measures. Those plants which are found to be most sensitive and to respond quickly might also serve a useful purpose as indicators of air pollution.

Goal 2–b.

Estimated present effort, FY 1960		$1,145,000
Recommended level of effort:		
Federal Government	$1,000,000	
Industry	700,000	
States & communities	1,000,000	
Total annual effort		$2,700,000

The recommended level of effort should be reached in 3 years and maintained for the remainder of the 10-year period.

Goal 3.

ECONOMIC LOSSES DUE TO DAMAGE TO MATERIALS, SOILING, AND REDUCED VISIBILITY: To develop techniques for the measurement of economic losses due to corrosion and other damage to materials, soiling, and reduced visibility; and to conduct surveys to obtain reliable cost estimates on both local and national bases.

There is considerable variation in the estimates which have been made of the economic costs of air pollution. The more recent estimates of these costs, for example, have ranged from $4 billion to $7.5 billion* annually, including agricultural losses but excluding costs related to health impairment. Basic, workable techniques of cost estimation should be developed, with follow-up pilot field surveys for purposes of validation, to assist public bodies and industry in understanding the magnitude and nature of their air pollution problems and in establishing priorities for action in control programs. In addition to the development of economic assessment methodology, studies should include related areas such as potential by-product use, economic motivation techniques (such as rapid tax amortization), and the social effects of polluted air on people and communities.

*Source: Gustavson, Ruben G., What Are the Costs to Society? Proceedings, National Conference on Air Pollution, November 1958.

Goal 3.

Estimated present effort, FY 1960		$100,000
Recommended level of effort:		
Federal Government	$150,000	
Industry	250,000	
States & communities	175,000	
Total annual effort		$575,000

The recommended level of effort should be reached in 2 years and maintained until techniques have been developed and applied (about 1967) to obtain estimates of economic losses on a national basis. Thereafter, surveys could be made at intervals of approximately 5 years to determine trends.

Goal 4.

MEASUREMENT AND IDENTIFICATION: To develop suitable methods and instrumentation for measurement and identification of air pollutants at sources and in community atmospheres.

Adequate instrumentation for sampling and analyzing at reasonable cost, and for the continuous monitoring of air pollutants, has been recognized repeatedly as a basic need.

Much can be accomplished by using instruments and methods now available for the measurement of dustfall, smoke, and several common gaseous contaminants. However, many of the instruments which are now available are limited in their general applicability due to their relatively high cost. Along with the development of new methods of measuring air contaminants, there is great need to make existing methods commercially available at lower cost so that they can be more widely applied.

For a number of substances, methods have been developed to obtain average concentration results from samples taken for periods of 24 hours or longer. For a small number of the simpler gases, such as sulfur dioxide, hydrogen sulfide, and carbon monoxide, minute-by-minute variations in concentration can be recorded continuously. Among other substances for which such continuous recording would be desirable are aldehydes, olefins, and polynuclear aromatic compounds. Such continuous measurement is necessary because air pol-

lutant effects are related not only to average concentrations over extended periods but also to higher concentrations which occur over shorter time intervals.

The art of sampling and analysis of particulates at their source is deficient from the point of view of automatic continuous instrumentation. There is need for practical methods for plume evaluation, for sensing continuously the weight of particulates emitted from stacks, and for determining the number of particles and the size distribution. This type of instrumentation is essential if reasonable use of the air is to be permitted and adequate control of potential sources of pollution is to be maintained.

Instrumentation for the analysis of gases at the source is also needed, for example, (1) for total organics from industrial operations such as those involving solvent emissions and (2) for automobile exhausts. Instrumentation for the detection and quantitative determination of odors is also required for adequate control of odor sources, and for the conduct of surveys. The low concentration in which some air pollutants constitute a nuisance due to odor adds to the complexity of this problem.

The availability of adequate low-cost equipment and techniques for the sampling and analysis of air pollutants is essential if a reasonable rate of progress is to be achieved toward these goals.

Goal 4.

Estimated present effort, FY 1960		$750,000
Recommended level of effort:		
Federal Government	$1,250,000	
Industry	900,000	
States & communities	350,000	
Total annual effort		$2,500,000

The recommended level of effort should be reached in about 3 years and maintained until the seventh year, at which time it could begin to decrease.

Goal 5.

METEOROLOGY: (a) To develop suitable methods and instrumentation for the identification and measurement of meteorological factors related to air pollution, and (b) to delineate factors governing the dispersal of pollutants from single and multiple sources.

The ability of the atmosphere to disperse concentrations of pollutants varies tremendously. Some of the variations are governed by physical laws which are well known. Intensified research is needed, however, to obtain more information, under a variety of conditions of topography and meteorology, on the factors affecting air movement, such as the turbulent structure of the wind and low-level temperature and wind gradients.

The two aspects of the goal in meteorological research may be described more specifically as follows:

Goal 5–a. *Instrumentation:* There is an urgent need for inexpensive, reliable instruments to provide aerometric measurements over urban areas up to about 5,000 feet above ground level. Approximately one-half of the total effort on this goal should be spent on the development of a practicable vertical probe. Reliable techniques for the prediction of meteorological conditions favorable to severe air pollution episodes also are required.

Goal 5–a.

Estimated present effort, FY 1960		$350,000
Recommended level of effort:		
Federal Government	$300,000	
Industry	100,000	
States & communities	0	
Total annual effort		$400,000

The recommended level of effort should be reached in 1 year and maintained for 4 years, after which it could be decreased.

Goal 5–b. *Dispersive Studies*: Satisfactory quantitative estimates of the capacity of the atmosphere for transporting and dispersing airborne contaminants are required for an objective evaluation of a community air pollution problem and, in particular, for the framing of effective regulatory measures.

The fundamental scientific problem is that of establishing suitable relationships between dispersive capacity and meteorological parameters that serve as direct indicators of turbulent mixing. These relationships may then be used to predict the three-dimensional distribution of airborne material, under a wide variety of weather conditions, emitted from sources of known characteristics. Objective determination of reasonable emission rates and the degree of control required for single sources in a given community are dependent to a considerable extent on this research. Several government agencies such as the Weather Bureau and the Atomic Energy Commission also have an interest in this problem. Both industry and government, therefore, have a responsibility to support and conduct research programs to delineate factors governing the dispersal of pollutants from single and multiple sources.

Goal 5–b.

Estimated present effort, FY 1960	$650,000
Recommended level of effort:	
Federal Government	$500,000
Industry	200,000
States & communities	50,000
Total annual effort	$750,000

The recommended level of effort should be reached in 1 year and maintained for 4 years, after which it could be reduced.

Goal 6. ATMOSPHERIC REACTIONS: To determine the potential for formation of atmospheric reaction products inherent in mixtures of primary pollutants.

Intensified research is needed with the object of obtaining more information on the ultimate interaction and fate of pollutants,

especially at times of atmospheric temperature inversion when the concentration of pollutants is likely to be greatest.

Since it has been established that interactions among primary pollutants, often energized by sunlight, produce both stable and transient products which have corrosive, toxic, or irritating properties, intensive research is called for to delineate the types of such reactions and the rates at which they form objectionable compounds. For example, the formation of ozone and other oxidants characteristic of Los Angeles atmosphere is known to result from a series of free radical reactions among relatively innocuous gases at concentrations of a very, very low order. Control of such secondary reactants requires identification of the participating primary pollutants and determination of the relative importance of each in the photochemical processes.

Research on reaction rates and mechanisms at low gas concentrations is relatively new, exacting, and enormously difficult technically. Generally the work will progress in proportion to sucess attained in elaborating investigative techniques. This will be especially true in those cases requiring direct identification or evaluation of free radicals in dynamic atmospheric systems.

The identification of primary reactants associated with secondary toxicants will facilitate the development of more effective and less costly controls. Also, adequate knowledge of the intermediate and secondary products is essential to understanding of health effects. This type of research requires a variety of highly skilled individuals and advanced instrumentation, and will become even more important as control efforts become more specific. Ideally, it is believed that this area of research should have much greater attention. However, the requirement for very skilled technical capabilities serves as a practical limitation on the degree of expansion of such research.

Goal 6.

Estimated present effort, FY 1960		$500,000
Recommended level of effort:		
Federal Government	$500,000	
Industry	300,000	
States & communities	200,000	
Total annual effort		$1,000,000

The recommended level of effort should be reached in 2 years and maintained for the remainder of the 10-year period, due to the complexities of this type of research and its basic importance.

Goal 7.

SURVEYS AND MONITORING: To conduct air pollution surveys of States and communities and to monitor air pollution by means of national, State, and community sampling networks.

This goal is concerned with the appraisal and surveillance of air pollution to determine the nature and extent of the problem, and to establish long-term trends.

Surveys to characterize the air pollution problem in a community or a State, or on a regional basis, are requisite to any planned control program and to formulation of State legislation and community ordinances which will be effective but not unduly restrictive. Having determined the problem and established reasonable legislation and control programs, communities should assess continually or periodically the nature and extent of air pollution within their boundaries. Such assay is basic to delineation of trends in magnitude and characteristics of air pollution problems and to analysis and understanding of health and other effects of air pollutants.

Such surveys and evaluations not only include air sampling but also must make use of all approaches to assay and assess the problem. Thus, emission inventories and surveys of effects on agriculture, health, and the economy must be integrated. Frequently, the only outward evidence of a problem, new or continuing, is the damage and other effects which it causes, and these must be taken into account, therefore, as a measure of the problem. The cost of many of these approaches may in part be borne in those figures given under other research goals. However, the cost for their correlation and analysis, when used as a means of assay, is included in this section.

Monitoring of individual sources for control and enforcement alone is not considered to be research in the context of this Report. However, the collection, correlation, and analysis of data for the determination of pollutional trends is considered to be within the purview of this Report.

A national network based on only one sampling site per community is inadequate to determine the distribution of pollutants within communities or specific regions. The assessment of air pollution problems as these are related to the unique topographic, industrial, and meteorologic characteristics of individual communities or regions should be the responsibility of the States and their subdivisions. Thus, State networks are required to characterize adequately the

air pollution problems within their boundaries and local monitoring programs should be conducted by communities at sites sufficient in number to assay the local problem. This sampling should be conducted in such a manner that results can be assimilated into State and national networks.

Particulate sampling, as now being conducted by the National Air Sampling Network, should be continued and additional communities of over 50,000 population should be added to the network. Gas sampling should be initiated to establish the distribution and trends of gaseous pollutants throughout the United States. The need for data on gaseous pollutants is of highest priority.

The only pollutants which have been systematically measured for over ten years are settleable solids, sulfur dioxide, and fluorides, and these only in a few localities. Moreover, many of the data on sulfur dioxide and fluoride are not available to the public. Much useful information could be obtained with little additional effort if the unpublished results of previous sampling by industry could be made available

The primary responsibility for the assay of air pollution through sampling and analyses should rest with States and communities. A major expansion of effort is required, there being only a few State and community networks in operation at the present time. The Federal Government should participate in the overall activity by continuation of its National Air Sampling Network and by the national collation and analysis of data from all sampling networks. It is recognized that industry does a considerable amount of source and atmospheric sampling and it is to be hoped that the data from these also will be made available to the Federal Government.

Goal 7.

Estimated present effort, FY 1960		$2,000,000
Recommended level of effort:		
Federal Government	$2,000,000	
Industry	500,000	
States & communities	5,000,000	
Total annual effort		$7,500,000

The recommended level of effort should be reached in 7 years and maintained for the remainder of the 10-year period.

Goal 8.

CONTROL: To develop new or improved methods and equipment for control of identified sources of air pollutants.

"Control" in this context encompasses research on all aspects of prevention of air contamination which may create a nuisance or which may be injurious to human health and welfare or to animals, vegetation, or other property.

Control of pollutants at the source by process design or modification is in general the most desirable approach. In most cases, however, specific equipment must be provided for containment of pollutants or for their removal from waste gases. In some cases, effective control is not economically feasible by either of these general procedures at the present time. To remedy this deficiency and to enable air pollution control technology to maintain pace with expanding and changing industrial activities, the Task Group considers essential an expansion of the current annual expenditure for this purpose. Although government has an appropriate role in the delineation of air pollution problems and the development of general approaches to their solution, the responsibility for development of methods for control of emissions resulting from industrial activities clearly lies primarily with the industries concerned.

Goal 8.

Estimated present effort, FY 1960		$2,800,000
Recommended level of effort:		
Federal Government	$500,000	
Industry	4,000,000	
States & communities	100,000	
Total annual effort		$4,600,000

The recommended level of effort should be reached by increasing the effort to $3,500,000 per year in 2 years and then increasing to $4,600,000 per year by the 10th year.

Goal 9.

INFORMATION, EDUCATION, AND TRAINING: (a) To maintain and provide for the dissemination of a comprehensive body of information related to the technical, economic, administrative, and legal aspects of air pollution, and (b) To assist in the development of trained manpower through the establishment and support of air pollution curricula at the graduate level, the support of individual trainees, and the conduct and support of short courses.

Goal 9-a. *Information:* Decisions and courses of action relating to air pollution control must be based upon adequate, sound information if they are to be realistic, efficient, and equitable. These decisions might range from those confronting a local legislative body considering an ordinance to those facing a plant manager in connection with the type of control measures to be installed.

Facilities for the organized accumulation, storing, indexing, and dissemination of available air pollution information should be established. A national clearinghouse of air pollution information should be operated by the Federal Government as the basic activity in this regard, complemented by supporting activities. The clearinghouse should emphasize completeness of available data information, with adequate facilities to service the States, communities, industry, and others on both routine and emergency bases. Rapid data retrieval and communications systems must be utilized if the mission is to be performed adequately.

Manuals of recommended practice for the common air pollution control processes should be prepared and published. A number of the processes are common to many industries and communities, and technical and industrial associations should assume basic responsibility for this activity. Governmental support should only be utilized where supplementation is needed.

Goal 9a.

Estimated present effort, FY 1960	$250,000
Recommended level of effort:	
Federal Government	$350,000
Industry	200,000
States & communities*	250,000
Total annual effort	$800,000

The recommended level of effort should be reached in 3 years and maintained for the remainder of the 10-year period.

*Includes educational institutions and non-profit associations in this instance.

Goal 9b. *Education and Training:* An expanded research program will depend on enlarging the inadequate number of persons now equipped for research in air pollution. The inter-disciplinary nature of air pollution highlights the need to provide some minimal training to specialists of different types, as part of their regular training.

Courses should be instituted which are designed to give such specialists as meteorologists, physicians, combustion engineers, et al. some orientation and training in related disciplines with which they will come into contact in air pollution work. A desirable goal is the inclusion of at least some instruction in air pollution, to be given as part of the regular training of physicians, engineers, meteorologists, et al. This should be largely a university responsibility in terms of adopting professional technical curricula to the needs of a changing society.

The present core group of universities offering full-time graduate-level air pollution curricula has a training potential which might handle a large share of the required specialized training. Some additional universities which have shown interest in this type of program should be encouraged to establish curricula to provide anticipated additional requirements. The programs of stimulating graduate-level training of air pollution specialists has been substantially supported by Federal funds for the past few years. There is a useful role for industrial educational assistance programs to provide some support

for desirable air pollution curricula in terms of industry's need for air pollution control specialists.

It is likely that, for some time, in order to insure a sufficient number of students, financial assistance for trainees will be required. The Federal Government should, as a minimum, triple its current traineeship program. States, localities, and industry should also contribute to a program of this type as their share in the goal of assuring an adequate supply of well-trained people.

The type of short-course training in technical subjects offered by the Public Health Service at the Sanitary Engineering Center should be encouraged. This type of training should also be expanded on a decentralized, regional basis and should be offered by universities as an extension-type curriculum. Some of the financial responsibility for this program should be borne by State and local control agencies, and by industry, through the payment of tuition fees for attendance of their personnel at such courses.

Goal 9b.

Estimated present effort, FY 1960		$350,000
Recommended level of effort:		
Federal Government	$500,000	
Industry	150,000	
States & communities	550,000	
Total annual effort		$1,200,000

The recommended level of effort should be reached in 3 years and maintained for the remainder of the 10-year period.

Goal 10. ADMINISTRATIVE AND LEGAL ASPECTS: To evaluate administrative and legal practices related to air pollution control.

Information concerning legislation, judicial decisions, and administrative regulations and procedures should be made currently available, and studies and appraisals of legal jurisdictional boundaries appropriate to the areas of air pollution sources, and public policies for dealing with them, should be supported.

State and community approaches to air pollution control have varied in several respects. Differences of opinion exist as to the degree

of control or regulation desirable at the local, State, or interstate levels and the best legal device to achieve equitable control. The performance approach and the specification approach both have adherents. The proper role of community planning and zoning in their relation to air pollution is marked by controversy. Research in all of these areas is needed to assist public bodies in making sound decisions.

Goal 10.

Estimated present effort, FY 1960		$15,000
Federal Government	$50,000	
Industry	0	
States & communities	50,000	
Total annual effort		$100,000

The recommended level of effort should be reached in 7 years and maintained for the remainder of the 10-year period.

Inter-Relationships of the Goals

The preceding section consists of a series of recommendations for levels of effort which are considered necessary if effective progress is to be made in understanding and coping with our air pollution problems. For convenience and ease of analysis these goals are presented as entities covering individual elements of the total effort needed. In actuality, however, these elements cannot be considered entirely independent of each other; in fact, some of the goals are heavily dependent on others. It is necessary, therefore, to consider these goals as a total effort.

Common to each of the goals in varying degree are the needs for adequate manpower and facilities. These are factors which have been considered in the recommendations concerned with the phasing of the individual goals and of the total effort. In some instances, the rates of increase of effort, or the deviations of maximum effort, are dependent upon successful accomplishments within other goals. For example, effective effort in portions of Goal 7, Surveys and Monitoring, is dependent to a large degree upon certain accomplishments in Goal 4, Measurement and Identification. Effective progress, therefore, cannot be made by placing undue emphasis on one, or even several, objectives at the expense of the others.

The present (FY 1960) total effort on each goal is an estimate based upon the best information available to the Task Group. In reaching these values the levels of current effort were taken into account. The ratios of projected to current effort are shown in table 1. Since the cost of different kinds of research varies widely, the sums recommended do not necessarily reflect the relative importance of the various goals. Although in several instances relatively small research funds are recommended, the goals are, nevertheless, extremely important.

The recommended levels of effort for each goal are summarized in table 1. The levels of total effort recommended for the Federal Government, industry, and States and communities, together with the approximate phasing of this support by years, is illustrated in figure 1. The maximum total effort to be expended in any one year of the ten-year program is approximately $32 million. The maximum annual expenditure for the Federal Government is about $13 million; for industry, $9 million; and for the States and communities, $10 million.

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NATIONAL GOALS IN AIR POLLUTION RESEARCH

Table 1

Goal	Level of effort in thousands of dollars						Phasing of effort—years		
	Present total effort fiscal year 1960 [1]	Ratio of recommended to present effort	Recommended annual expenditure during decade 1960–70 [2]						
			Total	Federal Government	Industry [3]	Communities	Reach peak	Level until	Decline until
1. Effects on Man:									
Health Surveys	600	7.9	4,750	3,200	250	1,300	1965	1970	.....
Pathology and Physiology.	1,000	3.0	3,000	2,100	600	300	1963	1970	.....
Annoyance Effects	200	5.0	1,000	500	300	200	1963	1968	1970
2. Agricultural Effects:									
Surveys	550	2.7	1,500	100	900	500	1963	1970	.....
Mechanisms	1,145	2.4	2,700	1,000	700	1,000	1963	1970	.....
3. Economic Losses	100	5.6	575	150	250	175	1962	1967	1970 [4]
4. Measurement & Identification.	750	3.3	2,500	1,250	900	350	1963	1967	1970
5. Meteorology:									
Instrumentation	350	1.1	400	300	100	0	1961	1965	1970
Dispersive Studies	650	1.2	750	500	200	50	1961	1965	1970
6. Atmospheric Reactions	500	2.0	1,000	500	300	200	1962	1970	.....
7. Surveys & Monitoring	2,000	3.8	7,500	2,000	500	5,000	1967	1970	.....
8. Control	2,800	1.6	4,600	500	4,000	100	Reach 3.5 million by 1962, then increase to 4.6 million by 1970		
9. Information, Education & Training:									
Information	250	3.2	800	350	200	250	1963	1970	.....
Education & Training	350	3.4	1,200	500	150	550	1963	1970	.....
10. Administrative & Legal Aspects.	15	6.7	100	50	0	50	1963	1970	.....

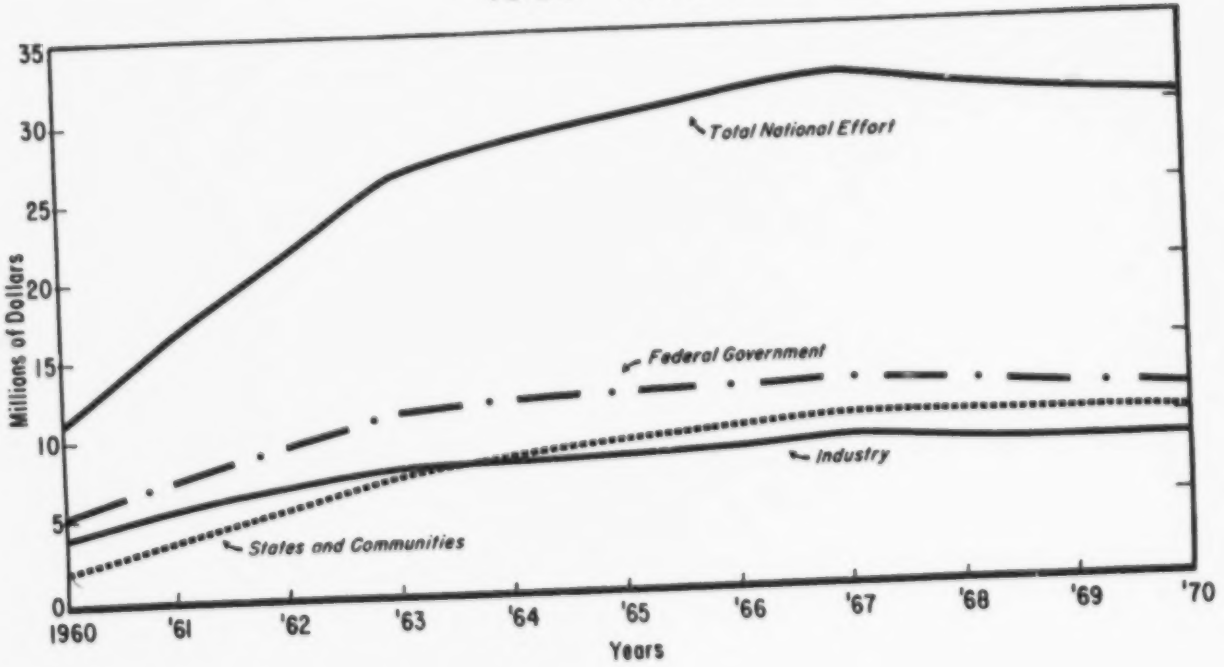
[1] Present total effort, fiscal year 1960: Federal Government, $5,275,000: industry, $4,065,000; States and communities, $1,920,000; total, $11,260,000.

[2] Values shown are maximum annual expenditures for each goal, which, due to phasing, do not all occur in any one year.

[3] See definition of industry, page 15.

[4] After techniques have been developed and economic losses determined, surveys could be made at intervals of approximately five years to determine trends.

RECOMMENDED NATIONAL EFFORT IN AIR POLLUTION RESEARCH
1960 - 1970



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